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USSR REPORT  
PHYSICS AND MATHEMATICS

No. 84

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## SCATTERING OF SECOND HARMONIC OF ACOUSTIC WAVE IN LIQUID WITH GAS BUBBLES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 1, Jan-Feb 83  
(manuscript received 7 Dec 81) pp 104-107

SOKOLOV, A. Yu. and SUTIN, A. M., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] A nonlinear acoustic method is considered for diagnosis of gas bubbles in a liquid, namely generation of the second harmonic of a sound wave and superposition of the fields scattered by individual bubbles in the case of low bubble concentration, in the single-scattering approximation. A spherically diverging wave of a frequency equal to double the frequency of the incident sound wave is assumed to appear in the acoustic signal scattered by a bubble, the model of a homogeneous medium being basically not applicable here. The mean intensity of this second harmonic is calculated for a  $\delta$ -distribution of bubbles with respect to size (radius), it has a coherent component and a noncoherent one. A typical situation is that of a bubble layer at some distance from a flat plunger emitting an acoustic wave at fundamental frequency. In the special case of bubbles of one size only the mean intensity of the second harmonic reduces to that of the second harmonic in a plane wave and at some critical bubble concentration its two components become equal. Above this concentration the coherent component becomes increasingly predominant till, at a sufficiently high bubble concentration, the homogeneous model becomes applicable. In the more general case of an arbitrary size distribution of bubbles those resonating at the fundamental frequency are the principal contributor to the noncoherent component of mean intensity and those resonating at the double frequency are the principal contributor to its coherent component. In this case, too, above a certain critical bubble concentration the homogeneous model will become applicable to the second harmonic. These relations are illustrated by specific examples with numerical data such as sea water. Figure 1, references 15: 12 Russian, 3 Western.

[38-2415]



## PERFORMANCE OF HORIZONTAL LINEAR ANTENNA IN SHALLOW SEA

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 1, Jan-Feb 83  
(manuscript received 31 Mar 81, after correction 20 Apr 82) pp 44-49

YELISEYEVNIN, V. A., Institute of Acoustics imeni N. N. Andreyev, USSR  
Academy of Sciences

[Abstract] A long horizontal linear antenna is immersed in a homogeneous plane-parallel water layer resting on a half-space which contains a heavier liquid, the classical Pekeris model of shallow sea, and its directional characteristics are calculated in terms of its response to a tone signal from a far point source also immersed in this water layer. The free upper surface of the water layer is assumed to be perfectly soft (air), with a reflection coefficient  $R = -1$ . The acoustic velocity is assumed to be higher in the liquid underneath, constant in both media. The tone signal appearing at the antenna is represented as a sum of normal incident waves, their field decaying very slowly with increasing horizontal distance  $r$  ( $A \propto r^{-1/2}$ ), while the field of the refracted wave decays very fast with increasing horizontal distance  $r$  ( $A \propto r^{-2}$ ) and this wave is assumed not to reach the antenna. The response of the antenna is found to consist of an energy component (single sum) and an interference component (double sum). First absorption is disregarded altogether, then absorption in the liquid underneath the water layer is taken into account. The response pattern is qualitatively similar to that in the case of a water layer on a perfectly solid bed, an antenna in an ideal waveguide. Figures 4, references 4: 3 Russian, 1 Western.  
[38-2415]

UDC 534.26

## NEW LOW-FREQUENCY AND INFRASONIC RESONANCE-TYPE SOUND ABSORBER

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 29, No 1, Jan-Feb 83  
(manuscript received 20 Aug 81) pp 5-10

VELIZHANINA, K. A. and OBOROTOV, V. A., Department of Physics, Moscow  
State University imeni M. V. Lomonosov

[Abstract] A new form of resonance-type sound absorbers is proposed for abatement of not only low-frequency but also particularly harmful infrasonic noise. Its main feature is a diffracting shield (disk) inside the cylindrical resonator cavity coaxially between the center hole in the front panel and the rigid back wall. Such a shield increases the apparent mass of air in the inlet hole and thus the resonator inertia so as to sufficiently lower its natural frequency with given wall thickness and small cavity depth, while viscosity and thermal conductivity of the air between inlet hole and

diffracting shield are adequate for ensuring the necessary dissipation losses. The effective inertia of such a resonator is calculated by the method of normal waves for a single aperture in the barrier of a waveguide with rigid walls. The corresponding acoustic field equation is solved for the velocity potential in the two regions separated by the shield and the solutions are collocated at the boundary between them. The effect of a pressure gradient due to convective accelerating forces and viscous forces is evaluated, the ratio of the former to the latter being much larger than the ratio of distance between inlet hole and shield to radius of inlet hole but smaller than this ratio squared. The dependence of the natural frequency of the resonator on the distance from inlet hole to shield and the frequency dependence of the normal absorption coefficient have been calculated theoretically on this basis and measured in an experiment with various ratios of hole radius to cylinder (resonator) radius. A comparison with the corresponding characteristics of resonator without shield confirms the effectiveness of inserting one. Figures 5, references 5: 4 Russian, 1 Western.  
[38-2415]

#### NONLINEAR RESONANT ATTENUATION OF SOUND IN LIQUID WITH GAS BUBBLES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 3,  
12 Feb 83 (manuscript received 9 Nov 82) pp 173-176

MAKSIMOV, A. O., Pacific Oceanological Institute, USSR Academy of Sciences,  
Vladivostok

[Abstract] Propagation of sound through a liquid with gas or vapor bubbles is analyzed from the standpoint of sound-bubble interaction. Both linear vibrations of a bubble with scattering of sound waves near resonance by a mechanism analogous to Landau attenuation and then nonlinear vibrations of a bubble like an anharmonic oscillator due to compressibility of gas are considered. Another factor affecting resonance is an external pressure field, above the critical intensity of which there appears a hysteresis with an amplitude jump in the amplitude-frequency characteristic. This effect is analyzed quantitatively by first calculating the transmission coefficient for a sound wave in a liquid with gas bubbles in the single-scattering approximation and then solving the Rayleigh-Plesset equation for bubble vibrations in the acoustic approximation for the velocity potential of a sound wave, with an effective damping coefficient which takes into account heat transfer and viscous friction as well as reradiation. This equation is solved by the method of asymptotic expansion with respect to the small parameter  $\alpha/R_0$  ( $\alpha$  - amplitude of vibrations,  $R_0$  - radius in bubble) in vicinity of the fundamental resonance. The solution depends largely on the mode of field application, slow or fast. The phase portrait and the resonance curve reflect a transition to dynamic instability as the critical pressure is reached slowly, with the curve bending to the right (toward higher frequencies) when the critical pressure is reached and exceeded fast. Figure 1, references 4: 3 Russian, 1 Western.  
[34-2415]

## COLLECTIVE SELF-STRESS OF SOUND IN LIQUID WITH GAS BUBBLES

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 37, No 1, 5 Jan 83 (manuscript received 4 Oct 82) pp 5-8

KOBELEV, Yu. A. and OSTROVSKIY, L. A., Institute of Applied Physics,  
USSR Academy of Sciences

[Abstract] A liquid containing gas bubbles is capable of such self-induced effects as self-focusing of sound. In the case of such mechanisms as the cavitation effect and self-stress due to cubic nonlinearity, such effects require fairly intense acoustic fields. The authors suggest a more efficient mechanism (in the sense of low threshold intensities) for self-stress of sound involving redistribution of bubbles in space due to averaging of the forces of radiation pressure and interaction between bubbles. Description of the collective behavior of bubbles in the field of an intense acoustic wave is described by hypotheses analogous to those used in plasma physics: the influence of the external field on an isolated bubble is described by introducing an average macroscopic field, disregarding its incoherent component as well. Oscillations of an isolated bubble are taken as linear. Specific effects are examined in the one-dimensional formulation, disregarding the influence of bubbles formed by coagulation, and assuming uniformity of bubble size at time zero. Effects that are new to acoustics include self-stress of a traveling wave, acoustic self-clearing and shock waves of envelopes. Figure 1, references 7 Russian.  
[29-6610]

## ANOMALOUS DAMPING OF ULTRASOUND UNDER THE ACTION OF AN ELECTRIC FIELD IN SUPERIONIC CRYSTALS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 37, No 1, 5 Jan 83 (manuscript received 15 Nov 82) pp 33-35

SKRITSKIY, V. L., SAMULENIS, V. I. and TEL'NOVA, G. B., Vilnius State  
University imeni V. Kapsukas

[Abstract] An investigation was made of the influence that a constant electric field has on propagation of ultrasonic waves in superionic crystals of  $\text{RbAg}_4\text{I}_5$  and Na- $\beta$ -aluminum oxide. The specimens were cut from single crystals and appropriately prepared for ultrasonic measurements. Dimensions of the specimens were  $0.4 \times 0.5 \times 0.5$  cm and  $0.5 \times 0.6 \times 0.6$  cm. Pulsed ultrasound was used in the 20-60 MHz range at room temperature. The longitudinal ultrasonic wave was propagated in direction [001] of the  $\text{RbAg}_4\text{I}_5$  crystal, and along the conductive planes in the alumina crystal. The constant electric field was set up both along and across the ultrasonic wave vector. It was found that in the presence of the electric field the coefficient of absorption of ultrasound slowly increases and reaches an anomalously high value for the given frequency. The velocity of propagation of the ultrasonic wave decreases. The effect shows up for electric fields in both

directions for  $\text{RbAg}_4\text{I}_5$ , but only for the field parallel to the ultrasonic wave vector for Na- $\beta$ -aluminum oxide. The observed anomalous damping of ultrasound in the presence of an electric field is apparently common to all superionic crystals and should be further investigated theoretically and experimentally. Figures 2, references 6: 5 Russian, 1 Western.  
[29-6610]

UDC 539.12.04:539.219

KINETIC EQUATIONS AND STABILITY ANALYSIS OF IRRADIATED MATTER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 1, Mar 83  
(manuscript received 2 Aug 82) pp 97-101

DEVYATKO, Yu. N. and TRONIN, V. N., Moscow Institute of Engineering Physics

[Abstract] Long action of radiation on matter results in an unstable behavior of the latter, manifested by formation of vacancy pores, precipitation of phases, amorphization and other effects. This behavior is described here by kinetic equations in the diffusion approximation, not in the standard form (which does not yield unstable solutions) but in a phenomenological modification. The system of these equations describes the behavior of point defects in a monatomic model substance bombarded by atoms of another kind. The diffusion current of impurity atoms entering the interstices in the host substance consists of two components, one due to their concentration gradient and one due to the vacancy gradient in the host substance. This system of equations has automatically at least two corresponding kinds of unstable solutions, representing a buildup of impurity concentration or vacancy concentration respectively. Two kinds of a new phase can nucleate, a vacancy pore or an impurity bubble. There can occur two kinds of fluctuations in the behavior of the host substance, plain temperature fluctuations and fluctuations caused by nonuniform nucleation of radiative defects. Article was presented by Academician A. B. Migdal 2 August 1982. References 5: 4 Russian, 1 Western.  
[41-2415]

GENERATION OF SECOND LIGHT HARMONIC IN CRYSTALS WITH RESONANT IMPURITIES

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 37, No 2, 20 Jan 83 (manuscript received 2 Dec 82) pp 85-86

ZEL'DOVICH, B. Ya. and KUZ'MICHEV, S. D., Moscow Physics-Technical Institute

[Abstract] The second harmonic of light is usually generated using transparent crystals without a center of symmetry for which the quadratic polarizability



tensor is not equal to zero. This article studies a special case in which the medium contains resonant impurity centers. The authors note that the dipole field in such a medium can effectively excite polarization at the double frequency in a nonresonant matrix material. A strong oscillating dipole moment is induced by a light wave in strongly absorbing impurities with a narrow transition line in which self-induced transparency can occur. The effects have been experimentally observed. References 3: 2 Russian, 1 Western.  
[40-6508]

#### RESONANT TRANSFORMATIONS OF ELECTROMAGNETIC SURFACE WAVES ON GERMANIUM SURFACE EXPOSED TO INTENSE LASER EMISSION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 2, 26 Jan 83 (manuscript received 25 Oct 82) pp 65-68

PROKHOROV, A. M., SYCHUGOV, V. A., TISHCHENKO, A. V. and KHAKIMOV, A. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Previous research has shown that electromagnetic surface waves induced in semiconductors by intense laser radiation give rise to periodic structures. In this paper an analysis is made of the kinetics of formation of such gratings with incidence of TE-polarized waves on germanium. The periodic structure in this arrangement has a period  $A \approx \lambda / \cos \theta$ , where  $\theta$  is the angle of incidence. The diffraction efficiency of the grating is studied as a function of the number of laser pulses. At a given intensity of the incident beam, the depth of the grating reaches a maximum at the instant when losses due to wave radiation on the grating become equal to dissipative losses. As exposure time increases, the decreasing diffraction efficiency of the main grating is accompanied by the formation of two new gratings turned through an angle  $\gamma_1$  and  $\gamma_2 \approx -\gamma_1$  relative to the main grating. The mechanism of formation of these gratings involves excitation of two new surface waves that interact resonantly through the initial grating in the first order of diffraction. Interference between the newly formed surface waves and the incident waves gives rise to the new gratings, which deepen with continued exposure. The resonant process is described, and a vector diagram is given. Figures 3, references 3: 2 Russian, 1 Western.  
[31-6610]

ELECTRIC BREAKDOWN OF ALKALI HALIDE CRYSTALS WITH PULSED IRRADIATION BY  
INTENSE ELECTRON BEAMS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 1,  
12 Jan 83 (manuscript received 18 Mar 82, after revision 15 Oct 82) pp 15-18

LISITSYN, V. M. and OLESHKO, V. I., Tomsk Polytechnical Institute  
imeni S. M. Kirov

[Abstract] Alkali halide crystals are exposed to pulsed electron beams with average particle energy of 0.25 MeV, pulse duration of 35 ns on the base, and current of about 1 kA. A focusing dielectric tube produced current density on the crystal of 1.5 kA/cm<sup>2</sup>. Experiments on electric breakdown of the crystals were done at room temperature and pressure of about 0.05 mm Hg. The specimens were KCl, KBr, NaCl, NaBr and LiF crystals 1-10 mm thick placed on flat grounded electrodes or on pointed electrodes to localize the breakdown channel. Electron bombardment was accompanied by an intense flash of plasma luminescence on both sides of the specimen and in the body. The zones of occurrence of the plasma correspond to zones of surface and volumetric destruction. After the pulse, crystal fracture is observed on the side opposite to the irradiated surface on the spot corresponding to the electrode point. The depth of the breakdown channel increases with each succeeding pulse. Puncture is complete after 1-5 pulses, depending on beam intensity, thickness and material of the specimen. Formation of the channel is accompanied by cracking of the specimen, and terminates with its destruction. If a metal plate is placed on the crystal at the point of incidence of the beam, plasma channels are formed in the body of the dielectric just as with direct exposure. Grounding of the metal plate completely eliminates plasma formation in the body of the specimen. Breakdown channels develop along definite crystallographic directions. Analysis of the dynamics of electric breakdown shows that interaction of an intense electron beam with ionic crystals gives rise to an electric field within the specimens that is associated with the space charge of the beam itself and with thermalized electrons. Field intensity at the instant of exposure reaches values sufficient for impact ionization to begin. The development of an electron avalanche then leads to formation of a positive streamer that advances into the specimen. Thus part of the energy of beam-dielectric interaction is converted to energy of the plasma formed beyond the region of electron travel. Volumetric breakdown of specimens thicker than the depth of electron penetration may be determined not only by thermal impact from the region of energy release of the penetrating particles, but also by electric breakdown, which is a much more efficient process. Figures 2, references 4 Russian.

[30-6610]



KINETICS OF CORRUGATION FORMATION ON GERMANIUM SURFACE WITH EXPOSURE TO  
INTENSE LASER RADIATION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 8, No 23,  
12 Dec 82 (manuscript received 27 Aug 82) pp 1409-1413

PROKHOROV, A. M., SYCHUGOV, V. A., TISHCHENKO, A. V. and KHAKIMOV, A. A.,  
Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] One of the mechanisms that has been suggested for the formation of periodic structures when intense laser emission acts on solids is interference between the incident wave and a hypothetical electromagnetic surface wave that arises in the solid upon exposure. To bring further arguments in favor of this hypothesis, the authors study the diffraction efficiency of a grating that arises on the surface of germanium as a function of the number of YAG laser pulses acting on it. The results show that diffraction efficiency first increases, then reaches a maximum and begins to fall. The behavior of this dependence varies with a change in beam intensity and angle of incidence. Theoretical analysis of the experimental data seems to favor the hypothesis of an interference mechanism involving an electromagnetic surface wave that gives rise to the periodic structure on semiconductor surfaces exposed to intense laser radiation. Figure 1, references 7:

3 Russian, 4 Western.

[23-6610]

UDC 533.6.011.72

SHOCK WAVES FORMING IN WATER DURING COLLAPSE OF CAVITATION BUBBLE

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 53, No 2, Feb 83  
(manuscript received 12 Apr 82) pp 311-314

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[Abstract] An experimental study was made of shock wave dynamics in water during collapse of cavitation bubbles. Shock waves were photographed by the schlieren method between two parallel mirrors 5 m apart and their velocity was measured with two OGM-20 lasers operating in synchronism. Double exposure was obtained with a pulse from the probing laser by means of a light beam splitter and an optical delay line, one part of the light beam traveling straight and one part traveling along a zig-zag path between two parallel side mirrors facing each other. A semiempirical relation was established for calculating the pressure at the shock wave-front. The results have revealed radial nonuniformities in the water during earlier stages of bubble evolution, appearing essentially after bubble expansion to maximum size and in the form of "filaments" which extend toward the center of collapse. These filaments in water were found only near breaks in the bubble wall and not around smooth segments of the bubble wall. The experiment has not confirmed the "microbubble" hypothesis, inasmuch as microbubbles were found to form during bubble expansion rather than during bubble collapse and to subsequently move at very low velocities. Figures 3, references 8: 7 Russian, 1 Western.  
[37-2415]

NEW KIND OF INSTABILITY OF LASER VAPORIZATION

Leningrad PIS'MA V ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 9, No 4,  
26 Feb 83 (manuscript received 26 Nov 82) pp 226-229

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[Abstract] A new kind of instability of vaporization by a laser pulse beam has been discovered, one which occurs during evaporation of thin films and has a space scale of the order of the film thickness. The possibility of this instability is demonstrated theoretically on a wafer of low thermal thickness and perturbation of the plane evaporation front due to heating and cooling, considering that not only the exposed surface but also the back surface of the film evaporates during passage of a laser pulse. The analysis is based on the theory of evaporation and the corresponding equations for the temperature field in a condensate body under an impinging energy flux, with appropriate boundary conditions. This instability has been established in an experiment with aluminum foils of various thicknesses and a CO<sub>2</sub>-laser (wavelength  $\lambda = 10.6 \mu\text{m}$ , TEM<sub>00</sub>-mode, plane polarization, beam divergence angle  $10^{-3}$  rad). Pulses with standard intensity "spike" of 200 ns duration and 10 s long "tail" were focused on the foil surface through an NaCl lens. The erosion spots had a relief in the form of concentric circular contour lines, indicating a radial spread of molten metal under a pressure gradient. The authors thank F. V. Bunkin for discussion and helpful comments. Figures 2, references 4 Russian.  
[35-2415]

## XeCl-LASER EMITTING PULSES OF 100 J ENERGY

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 4,  
26 Feb 83 (manuscript received 4 Dec 82) pp 201-203

BARANOV, V. Yu., VELIKHOV, Ye. P., GAYDARENKO, D. V., ISAKOV, I. M.,  
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SMAKOVSKIY, Yu. B. and STREL'TSOV, A. P.

[Abstract] An experimental study was made of an XeCl laser with electron-beam pumping and an external plane-mirror resonator. Electron beams of  $100 \times 15 \text{ cm}^2$  cross section and  $10^{-8} \text{ s}$  duration, 300 keV energy and  $40 \text{ A/cm}^2$  current density were produced by an electron gun with a Marx generator. The active medium was an Ar+Xe+CCl<sub>4</sub> mixture. The resonator was formed either by a plane-parallel quartz plate and a dull plane mirror with aluminum coating or by two plane dielectric mirrors with different reflection coefficients (0.3 and 0.7 respectively). The emission pulse shape was measured with a photocell and compared with oscillograms of the electron beam current and of the accelerating gap voltage. The emission energy was measured with a calorimeter and on the basis of the energy density distribution over the laser beam cross section. It was found to depend slightly on the CCl<sub>4</sub>:Ar ratio, the maximum energy density ( $1 \text{ J/cm}^2$ ) having been obtained with an Ar:Xe:CCl<sub>4</sub> = 200:20:1 mixture and a total emission pulse energy of 100 J having been obtained with an Ar:Xe:CCl<sub>4</sub> = 2000:20:1 (2.8 atm) mixture using a high-Q resonator. With a small-signal gain  $g_0 \approx 0.04\text{--}0.05 \text{ cm}^{-1}$  and a nonsaturating absorption coefficient in the active medium  $\alpha \approx 0.01\text{--}0.02 \text{ cm}^{-1}$ , the active-medium utilization factor was  $(1 - \sqrt{\alpha/g_0})^2 \approx 0.2$  approximately. Figures 2, references 4: 3 Russian, 1 Western.  
[35-2415]

## EFFECT OF POLYATOMIC GASES ON EFFICIENCY OF OPTICALLY PUMPED CHEMICAL HF-LASER

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 3,  
12 Feb 83 (manuscript received 12 Jul 82) pp 134-137

VELIKANOV, S. D., KORMER, S. B., SINITSYN, M. V., URLIN, V. D.,  
TACHAYEV, G. V. and SHCHUROV, V. V.

[Abstract] One possible method of increasing the output energy of a chemical HF laser is slowing down the temperature rise during the chemical reaction process and thus maintaining the active medium as long as possible within the most favorable temperature range of 500-800 K. This should be possible, theoretically, with the use of a polyatomic gas instead of helium as diluter, a gas with much higher specific heat and one which will ensure a low rate of relaxation of excited HF molecules but a high rate of trimolecular breakaway during preparation of the mixture. The feasibility of accomplishing this was established experimentally, using SF<sub>6</sub> or CF<sub>6</sub> as buffer gas for an HF

laser with optical pumping. The active mixture was 44 torr  $F_2$  + 14.7 torr  $H_2$  + 7.4 torr  $O_2$  +  $SF_6$  (or  $CF_6$ ), with helium as buffer gas in a control experiment. Replacing helium with  $SF_6$  or  $CF_6$  increased the laser output energy by 100% and 10% respectively, without significantly changing the time characteristics of the emission pulse and with the optimum pressure of the diluting gas reduced to one-eighth of that for helium. Most favorable is dilution with twice as much  $SF_6$  as with helium, to maintain the temperature within the 500-800 K range, excessive dilution being detrimental on account of enhanced quenching. Figure 1, table 1, references 5: 3 Russian, 2 Western.  
[34-2415]

#### SOME PARTICULARS OF NEODYMIUM NEEDLE LASER EMISSION

Tbilisi SOOBASHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 107, No 2, Aug 82 (manuscript received 16 Apr 82) pp 277-279

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[Abstract] The paper gives the results of investigation of the emission properties of lasers based on silicate glass activated with trivalent neodymium. The active element is in the form of a slender rod about 1 mm in diameter and about 40 cm long. Such lasers emit a series of giant pulses with duration of 20-40 ns and recurrence rate of up to 30 kHz. The experiments were done on lasers with polished end faces in a two-lamp reflector. A two-beam oscilloscope was used to record the lasing pattern simultaneously on two levels of sensitivity with two FEU-62 photomultipliers. The results show that pulses of two types are generated: periodic giant pulses with duration of 20-40 ns recurring after a pause of 30-40  $\mu s$ , and pulses with duration of 200-250 ns with amplitude an order of magnitude lower than the first type superimposed on the regular giant pulses. It is suggested that pulses of the first type result from stimulated emission of longitudinal modes mainly due to reflections from the polished ends, while pulses of the second type are caused by annular modes formed by reflections from the lateral surface of the cylindrical active element. Since the angles of incidence of these waves on the end faces are large, reflectivity increases, resulting in high Q of the cavity for these annular modes. Experiments were done with needle lasers in a liquid to suppress the annular modes. It was found that the lasing threshold decreases and the energy of useful emission increases as the ratio of the index of refraction of the glass to that of the liquid decreases. Figures 3, references 3.  
[27-6610]



# INCREASE IN RATE OF WATER MIST PARTICLE SETTLING RESULTING FROM ACOUSTIC ACTION OF CO<sub>2</sub> LASER PULSE

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 37, No 3, 5 Feb 83 (manuscript received 21 Dec 82) pp 139-141

BELOV, N. N., DAVYDOV, K. A., DATSKEVICH, N. P., KARLOV, N. V., KONONOV, N. N., KUZ'MIN, G. P., NEGIN, A. Ye., NESTERENKO, A. A., PAKHOMOV, A. V. and PROKHOROV, A. M., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] In experiments on fog dispersal the authors observe an increase in the rate of sedimentation of water mists as a result of acoustic perturbation set up in an aerosol by pulsed CO<sub>2</sub> laser emission. The effect occurs at energy densities much lower than with the formation of a dispersal channel, and with a considerable delay after the perturbing laser pulse. As 10- $\mu$ m radiation propagates in water mists, part of the energy of the laser pulse is absorbed by the particles and is expended on heating the gas. As this occurs, an acoustic disturbance is set up in the vicinity of the beam. Before the instant of action of the radiation, the system of water particles and saturated vapor is in a state of thermodynamic equilibrium. With the onset of acoustic perturbation, there is an increase in the partial pressure of water vapor, leading to disruption of equilibrium with condensation of vapor on the surface of the particles, thus enlarging the particles and accelerating sedimentation. Figures 2, references 6 Russian.  
[28-6610]

UDC 669.017.620.1:536.21

# OPTIMUM CONTROL OF EXOTHERMIC PROCESSES IN LASER THERMOCHEMISTRY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 3, Jan 83  
(manuscript received 24 Aug 82) pp 598-601

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[Abstract] The authors consider the dynamics of chemical processes initiated by heat delivered to a system by laser radiation. The response of the system involves feedback between chemical and thermal degrees of freedom due to change in the optical characteristics of the system. At the same time, important chemical processes are accompanied by release or absorption of the latent heat of reaction. The temperature dependence of the rate of these processes causes feedback between heat release and reaction rate. One of the more important processes of this type is heterogeneous oxidation of metals,

enabling utilization of the additional exothermic reaction heat in industrial laser applications. In this paper, an analysis is made for the purpose of tailoring a laser pulse to maximize heating of the oxidized metal while minimizing energy input. Formulas are derived that give a good approximation of the optimum mode of laser heating with combined action of cw and pulsed lasers. Figures 3, references 11 Russian.  
[26-6610]

#### LASER CONTROL OF RESONANT MOLECULE STREAM THROUGH CAPILLARIES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 2,  
26 Jan 83 (manuscript received 26 Oct 82) pp 69-72

KARLOV, V. N., ORLOV, A. N., PETROV, Yu. N., PROKHOROV, A. M., SURKOV, A. A.  
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[Abstract] Experiments show the controlling action of laser radiation on travel of resonant molecules through capillaries with inside diameter comparable with the mean free path of the molecules. The experiments were done on flow of molecular streams of  $SF_6$  and  $Br_2$  through capillaries of chalcogenide  $As_2S_3$  and molybdenum silicate glass respectively. In the case of  $SF_6$ , cw  $CO_2$  laser emission was used, which is resonant to  $\nu_3$  of the  $SF_6$  molecule, while in the case of  $Br_2$ , the controlling emission was provided by a cw argon laser that resonates with transition  $1\Sigma^+_{0g} \rightarrow B^3\Pi^+_{0u}$  of the bromine

molecule. The chalcogenide capillary was 29 mm long with inside diameter of 0.12 mm, and the glass capillary was 40 mm long with inside diameter of 0.15-0.2 mm. The outlet ends of the capillaries were directly connected to the vacuum chamber of a KM-2 quadrupole mass spectrometer. A reduction in resonant molecular flow was observed when laser radiation was coupled into the capillaries. Flow decreased by 40-45% within 1 s after switching the laser on, and recovered within 3 s after switching the laser off. The effect is attributed to retardation of molecular diffusion through the capillary under the action of laser radiation. It is shown that the polarizing action of resonant laser emission can be used to control the flow of molecules through capillaries for laser output in the visible and infrared bands. Figure 1, references 6 Russian.

[31-6610]



#### SCATTERING OF 1.06 $\mu\text{m}$ AND 0.53 $\mu\text{m}$ LASER EMISSION BY FLAT TARGETS

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 2,  
26 Jan 83 (manuscript received 26 Oct 82) pp 119-123

ANDREYEV, A. A., BAYANOV, V. I., KRYZHANOVSKIY, V. I., KRYLOV, V. N.,  
MAK, A. A., SEREBRYAKOV, V. A. and SOLOV'YEV, N. A.

[Abstract] An investigation was made of the spectral and energy characteristics of plasma-scattered light for different parameters of heating radiation with wavelengths of 0.53 and 1.06  $\mu\text{m}$ . A neodymium laser was used with master oscillator having pulse duration variable from 0.2 to 2 ns. Following the master oscillator, the radiation was amplified in a channel consisting of five amplifiers and three spatial filters. Diameter of the final amplifier was 60 mm. Emission divergence was  $2 \cdot 10^{-4}$  radian. Emission leaving the final stage was converted to the second harmonic by a KDP crystal. The output radiation was focused on the target by an aspherical lens with focal length of 100 mm. The minimum size of the focal spot was 30  $\mu\text{m}$ . Laser radiation energy ranged from 5 to 25 J. Flat targets of  $(\text{CH}_2)_n$  and  $\text{SiO}_2$  were placed at an angle of  $22^\circ$  to the axis of the incident beam to separate specular and backscattered components in the plasma-reflected radiation. A system of calorimeters was used to measure the energy of the scattered radiation. The results show stimulated Mandelstam-Brillouin scattering with efficiency that decreases with decreasing flux density and shorter wavelengths. Figure 1, table 1, references 6: 3 Russian, 3 Western.  
[31-6610]

#### $\text{SF}_6 + \text{H}_2$ LASER INITIATED BY INTENSE RELATIVISTIC ELECTRON BEAM

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 1,  
12 Jan 83 (manuscript received 15 Jul 82) pp 46-49

ZAVOROTNYY, S. I., IPATOV, A. L., MKHEIDZE, G. P., OVCHINNIKOV, A. A.  
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Sciences, Moscow

[Abstract] The paper gives preliminary results on stimulated emission by a laser using a mixture of  $\text{SF}_6 + \text{H}_2$  with beam initiation. Particular attention is given to problems of effectiveness of interaction of the relativistic electron beam with the gas mixture. The facility consisted of a Terek-1R electron accelerator, a laser cell, optical cavity, gas inlet system, and instrumentation for registration of the parameters of the relativistic electron beam and the laser emission. In the laser cell, the electron beam had the following parameters: electron energy 1.5 MeV, beam current 15 kA, current pulse duration 40 ns. The laser cell, intermediate chamber and accelerator diode were located in a longitudinal magnetic field of  $5 \cdot 10^5$  A/m. The laser cell had an active length of 200 cm and diameter of 12.8 cm. The cavity was formed by a flat opaque aluminized mirror and a plane-parallel LiF plate. The mirrors were 60 mm in diameter.

Maximum lasing energy of 8.5 J was produced in a mixture of  $\text{SF}_6:\text{H}_2:\text{Ar} = 7:1:6$ . Maximum beam energy input to the gas is 150 J at pressures exceeding 0.3 atm. The electric efficiency of the system, i.e. the ratio of the energy of laser radiation to the energy of the beam invested in the gas reaches 5.0% at the maximum laser output. All mixtures show an increase in efficiency to 8-10% in the region of pressures less than optimum. Figures 4, references 7: 5 Russian, 2 Western.  
[30-6610]

## NUCLEAR PHYSICS

### EXPERIMENTAL OBSERVATION OF HIGH ASPECT TARGET ENVELOPE COMPRESSION ON 'DOLPHIN-1' INSTALLATION

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 37, No 2, 20 Jan 83 (manuscript received 16 Dec 82) pp 109-112

BASOV, N. G., GALICHIY, A. A., DANILOV, A. Ye.; ISAKOV, A. I.,  
KALASHNIKOV, M. P., MERKUL'YEV, Yu. A., MIKHAYLOV, Yu. A., RODE, A. V.,  
SKLIZKOV, G. V. and FEDOTOV, S. I.

[Abstract] The "Dolphin-1" laser-driven fusion installation is a neodymium glass laser with series-parallel placement of amplifying stages forming 108 beams at the output grouped in 6 components of 18 elementary beams each. Envelope glass target heating experiments were performed on the installation with a delivered energy of 1 kJ, pulse length 2.3 ms, beam divergence  $1.2 \cdot 10^{-4}$  rad, energy contrast  $10^6$ . The focusing system achieves spherical symmetry at the target with target surface level modulation not over 7%. Results are presented from studies of compression of glass envelope targets illustrating the influence of radiation inhomogeneity on compression. Inhomogeneity resulted from the distribution of beams over the surface of the target (not over 20%) and difference in component beam energies. The experiments involving heating of envelope targets with an aspect ratio of about 200 showed that stable compression of targets can be achieved with high collapse velocities and high compressed core temperatures. Figures 3, references 6: 5 Russian, 1 Western.  
[40-6508]

### REAL PART OF FORWARD ELASTIC SCATTERING AMPLITUDE AND HIGH-ENERGY BEHAVIOR OF TOTAL CROSS SECTIONS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 37, No 3, 5 Feb 83 (manuscript received 31 Dec 82) pp 163-166

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[Abstract] Data on the behavior of total cross sections of particle interaction at high energies are necessary for the theory of strong

interactions and for studying processes of particle passage through matter. Data obtained directly in cosmic ray studies are of low accuracy, and extrapolation formulas are ambiguous. In this paper the authors discuss how these formulas agree with data obtained on the SPS collider at  $\sqrt{s} = 540$  GeV, where  $\sigma_t = 66 \pm 7$  millibarns. Predictions are made on the ratio of real and imaginary parts of the amplitude of elastic scattering at these energies and higher, if dispersion relations are used. It is shown that when this ratio is measured on the SPS collider, more precision is possible in selection of an extrapolation formula. Figure 1, references 7 Western.  
[28-6610]

# NEW MECHANISM OF ACCELERATING COSMIC PARTICLES IN THE PRESENCE OF REFLEXIVELY NONINVARIANT TURBULENCE

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 37, No 1, 5 Jan 83 (manuscript received 26 Sep 82) pp 43-45

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[Abstract] A variety of acceleration mechanisms are involved in formation of nonthermal spectra of high-energy particles (cosmic rays). The author considers a new mechanism of particle acceleration in the presence of reflexively noninvariant (gyrotropic) turbulence. Previous interest in gyrotropic turbulence stressed the capacity for generating magnetic fields ( $\alpha$ -effect). Thus the magnetic field dynamo and charged particle acceleration may be a consequence of a single effect. The efficiency of the proposed mechanism of acceleration is  $(\lambda/R)^2$  greater than that of Fermi acceleration, where  $R$  is the Larmor radius and  $\lambda$  is the mean free path before scattering by magnetic inhomogeneities. References 9 Russian.  
[29-6610]

# EXPLOSIVE REACTION OF NUCLEI INDUCED IN $^{238}\text{U}$ , $^{232}\text{Th}$ AND $^{197}\text{Au}$ TARGETS BY PROTONS WITH ENERGY OF 1 GeV

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI  
in Russian Vol 37, No 1, 5 Jan 83 (manuscript received 27 Nov 82) pp 60-63

GORSHKOV, B. L., IL'IN, A. I., SOKOLOVSKIY, B. Yu., SOLYAKIN, G. Ye. and CHESTNOV, Yu. A., Institute of Nuclear Physics imeni B. P. Konstantinov, USSR Academy of Sciences

[Abstract] A two-beam time-of-flight spectrometer is used to study the way that the mechanism of fission of  $^{238}\text{U}$ ,  $^{232}\text{Th}$ ,  $^{197}\text{Au}$  and  $^{184}\text{W}$  nuclei exposed to protons with energy of 1 GeV depends on nucleonic losses. Additional fragments emerging at right angles to the proton beam were registered by semiconductor detectors. Target thicknesses ranged from 100 to 500  $\mu\text{g}\cdot\text{cm}^{-2}$ .

The energy, mass and momentum of collinearly emitted additional fragments were measured. In addition to events of nuclear fission characterized by an average nucleonic loss of about 20 amu, events were also observed in which nucleonic losses were considerably greater than fission losses, reaching nearly half the initial mass of the target nucleus. The effect is most pronounced for  $^{238}\text{U}$ , and gradually falls off with a reduction in mass number of the target nucleus. These explosive reactions have their own specific kinematics of dispersal. The total kinetic energy in such events is greater than the fission energy for the same sum of masses of the resultant fragments. There is also a redistribution of kinetic energies between fragments completely violating the relation  $E_H \cdot M_H = E_L \cdot M_L$  that holds for dissociation of quiescent nuclei. This can be attributed to a perpendicular transfer momentum comparable in magnitude to that of the fission fragment. Figures 3, references 3: 2 Russian, 1 Western.  
[29-6610]

#### USING MULTIPLE-POINT EXPLOSIVE EMISSION CATHODE TO PRODUCE TUBULAR ELECTRON BEAM WITH DURATION OF $10^{-4}$ SECOND

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 1, 12 Jan 83 (manuscript received 26 Jul 82) pp 26-30

VASILEVSKIY, M. A., NIKONOV, A. G., ROYFE, I. M., SAVEL'YEV, Yu. M. and ENGEL'KO, V. I., Scientific Research Institute of Electrophysical Equipment imeni D. V. Yefremov, Leningrad

[Abstract] The paper gives the results of experiments in which a tubular electron beam with duration of  $10^{-4}$  s or longer was formed by using a multiple-point cathode. The experimental facility is described in another article [see V. A. Burtsev, M. A. Vasilevskiy, O. A. Gusev, I. M. Royfe, Ye. V. Seredenko, V. I. Engel'ko, PRIBORY I TEKHNIKA EKSPERIMENTA, No 5, 1979, p 32]. The electrode has a conical working surface with area of  $1.5 \cdot 10^3 \text{ cm}^2$  covered with 500 points made of carbon fibers. The cone has a paper angle of  $6.6^\circ$ . Screen electrodes in the upper and lower parts of the cathode unit improve the distribution of the electric field over the working surface. Magnetic field induction in the acceleration tube is 1.5 kGs, and in the drift channel—10 kGs. Oscillograms are given of the beam voltage and current, and a photograph is given of the cathode plasma luminescence. The results show that the perveance of the beam varies weakly throughout the pulse. With accuracy of 1.5%, beam current is given by the formula

$$I = \frac{8\pi}{9} \epsilon_0 \sqrt{2e/m} \frac{U^{3/2}}{r_A} \sin \alpha, \text{ where } r_A \text{ is the radius of the acceleration}$$

tube;  $U$  is voltage;  $\alpha$  is the angle at which the force lines of the magnetic field intersect the working surface of the cathode;  $e$  and  $m$  are the charge and mass of the electron respectively. The current in a cathode coil could be varied to change  $\alpha$  in the experiments. For optimum distribution of the magnetic field, the beam diameter is 4.5 cm, and width is 0.7 cm. Rate of expansion of the outer boundary does not exceed 1000 cm/s. Figures 2, references 4 Russian.

[30-6610]



UDC 535.135

DYNAMICS OF SHORT-DURATION HIGH-INTENSITY PULSES IN LIGHT GUIDE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 1, Mar 83  
(manuscript received 31 May 82) pp 105-108

SISAKYAN, I. N. and SHVARTSBURG, A. B., Institute of Physics  
imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Evolution of a high-intensity pulse in a light guide is analyzed, taking into account the simultaneous but opposing effects of dispersion and nonlinearity. One equation is used for the evolution of fundamental and higher modes of  $1s$  and TH-polarized pulses along the axis of a light guide with a parabolic radial profile of the refractive index and a cubic non-linear response of the refractive index to perturbation. The solution to the corresponding wave equation is sought in the form of an infinite series for the axial field component as a function of two polar coordinates and two "slow" variables related to the group velocity and a small parameter. The original field equation is thus converted to a series of equations of various orders with respect to the small parameter, the first-order equation describing the effect of dispersion and the third-order equation describing the effect of nonlinearity. Further transformations result in a nonlinear Schroedinger equation for the evolution of the pulse envelope. Solution of this equation as a reverse problem in the theory of scattering reveals the restructurization of a pulse characterized by its initial envelope, with formation of a narrow high-intensity peak. Subcritical and supercritical modes of pulse evolution are possible, depending on the duty factor of the pulse, nonlinearity inhibiting the effect of dispersion in the former case and producing shock waves with new independent peaks at the pulse periphery in the latter case. Article was presented by Academician A. M. Prokhorov 13 May 1982. References 5: 1 Russian, 4 Western.  
[41-2415]

# NONLINEAR SPACE-FREQUENCY CHARACTERISTICS OF THREE-DimensionALLY NONHOMOGENEOUS SCATTERING LAYER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 1, Mar 83  
(manuscript received 31 May 82) pp 84-87

SUSHKEVICH, T. A., MISHIN, I. V. and IOLTUKHOVSKIY, A. A., Institute of Applied Mathematics imeni M. V. Keldysh, USSR Academy of Sciences, Moscow

[Abstract] A mathematical model is proposed for describing the radiation field of a three-dimensionally nonhomogeneous atmospheric layer with distortions due to multiple scattering in that layer, rereflection at the bottom surface, and nonhomogeneity of that surface. The space-frequency characteristics of the radiation transmitting system are described by one-dimensional equations invariant with respect to changes in the volume scattering coefficient and in the albedo of the bottom surface. The intensity of monochromatic radiation in a given direction at a given point in space is calculated as the solution to the corresponding boundary-value problem with linear operators in the theory of transmission, with the point in space defined by Cartesian coordinates and the direction of radiation defined in polar ones. This solution is sought in the class of generalized functions admitting a Fourier integral transformation and representable in the form of series with respect to two parameters  $\epsilon, \nu$  according to perturbation theory, as the sum of two components: the

$$\sum_{n=0}^{\infty} \nu^n J_n \text{ -term describing un-}$$

scattered radiation and the

$$\sum_{k,n=0}^{\infty} \epsilon^k \nu^n \phi_{k,n} \text{ -term describing multiply scattered}$$

and rereflected radiation. The case  $k=0, n \geq 1$  corresponds to a homogeneous reflecting bottom surface and a spatially nonuniform scattering coefficient. The case  $n=0, k \geq 1$  corresponds to a horizontally homogeneous layer and a nonhomogeneous bottom surface, an approximation ( $k = 1$ ) most widely used in problems of atmospheric and space optics and in theory of vision through turbid media. The case  $k = 0, n = 0$  reduces to the plain scalar equation for the horizontally constant intensity component and mean illumination of the bottom surface. The authors thank M. V. Maslennikov for helpful discussions. Article was presented by Academician A. N. Tikhonov 20 May 1982. References 15 Russian.

[41-2415]



## ANALOGS OF BREWSTER ANGLES FOR ELASTIC SURFACE WAVES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 4,  
26 Feb 83 (manuscript received 15 Nov 82) pp 222-226

BIRYUKOV, S. V.

[Abstract] Scattering of elastic surface waves by surface inhomogeneities is considered and the existence of angles analogous to Brewster angles in this case is established. This is demonstrated on a transversely isotropic half-space with a rough horizontal surface and with the elastic moduli functions of the vertical coordinate only, its properties being completely described by the tensor of mechanical surface impedance relating the Fourier transforms of normal stresses to the Fourier transforms of displacements. Scattering of horizontally polarized waves with transverse displacements and of vertically polarized waves with normal displacement, two possible kinds of natural modes, by surface inhomogeneities is analyzed for determining the dependence of the "Brewster" angles on the ratio of inhomogeneity parameter to substrate parameter (velocities of transverse waves). A range of this ratio is found over which the two "Brewster" angles for a typical medium vary correspondingly from  $0^\circ$  to  $+86^\circ$  and from  $+180^\circ$  to  $+86^\circ$  respectively, there being no "Brewster" angle within the other ranges of this ratio. References 5 Russian.  
[35-2415]

## SPHERICAL AND PLANE MULTILAYER NORMAL-INCIDENCE MIRRORS FOR SOFT X-RADIATION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 4,  
26 Feb 83 (manuscript received 1 Dec 82) pp 208-213

GAPONOV, S. V., GUSEV, S. A., PLATONOV, Yu. Ya., SALASHCHENKO, N. N. and GLUSKIN, Ye. S., Institute of Applied Physics, USSR Academy of Sciences, Gorkiy

[Abstract] Plane dispersing mirrors and spherical focusing mirrors for soft X-radiation ( $\lambda = 45-200 \text{ \AA}$ ) were produced by deposition of alternating multilayer structures W-C (80 periods) or Au-C (30 periods) on quartz substrate surfaces. The reflection coefficient and the bandwidth of its angular distribution were measured with an X-ray diffractometer ( $\lambda = 1.54 \text{ \AA}$ ) using long-wave X-rays from a synchrotron, at an incidence angle of  $2.5^\circ$  for the plane mirrors and  $4^\circ$  for the spherical ones. The utilization factor, namely the number of periods of the multilayer structure participating in the reflection process, was determined for the plane mirrors from the location of secondary minima in the spectrum. The size of the focal spot, in the case of spherical mirrors, was found to be determined solely by the divergence of the synchrotron radiation flux. Figures 2, references 15: 6 Russian, 9 Western.  
[35-2415]

## EFFECT OF LASER RADIATION ON ABSORPTION WITHIN TAIL RANGES OF SPECTRAL LINES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 5, Feb 83  
(manuscript received 24 Oct 82) pp 1105-1107

AGEYEV, B. G., GORDOV, Ye. P., PONOMAREV, Yu. N., TVOROGOV, S. D. and  
CHISTYAKOVA, L. K., Institute of Atmospheric Optics, Siberian Department,  
USSR Academy of Sciences, Tomsk

[Abstract] Interaction of intense optical radiation and molecular gas is characterized not only by nonlinear optical effects within the resonance range but also by an intensity dependence of the absorption coefficient within the tail ranges of a spectral line. This dependence, due to the effect of a strong radiation field on the intermolecular interaction potential and on the tails of a spectral line on both sides of the peak, is here explained by a semiclassical method of analysis. The corresponding self-consistent system of three equations (equation of potential, Schroedinger wave equation for molecules with centers of mass moving along a classical trajectory, equation of the trajectory) is solved according to the theory of perturbations in the first approximation. The trend of the exponential intensity dependence of the potential reveals that the absorption coefficient either decreases or increases, depending on whether the potential in the absence of a field is respectively negative or positive. This interpretation was verified experimentally for the 010 vibrational-rotational band of  $H_2O$  vapor in the path of a  $CO_2$ -laser beam ( $\lambda=10.6 \mu m$  wavelength, 300 ns pulses). Measurements made by the optico-acoustic method and subsequent calculations yielded an absorptivity decreasing fast with increasing intensity, probably because of radiative breakdown of water aerosol particles under a pressure far below saturated-vapor pressure. Article was presented by Academician V. Ye. Zuyev 11 Oct 82. Figure 1, references 6: 5 Russian, 1 Western. [33-2415]

UDC: 551.521.3+535.361

## EXTREME DISTORTION OF IMAGES OF OBJECTS OBSERVED THROUGH A SCATTERING LAYER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 2, Jan 83  
(manuscript received 25 May 82) pp 321-324

ZUYEV, V. Ye., academician, BELOV, V. V., BORISOV, B. D., GENIN, V. N.,  
KABANOV, M. V. and KREKOV, G. M., Institute of Atmospheric Optics, Siberian  
Division, USSR Academy of Sciences, Tomsk

[Abstract] Basic results are presented from combined theoretical and experimental studies of the variation of image quality as a function of scattering layer position with small values of the parameter  $t = l/L$ , where  $l$  is the distance from the object to the nearest boundary of the layer, and  $L$  is

the distance from the object to the receiver, with severe image quality deterioration for small objects. Theoretical studies consisted of computer modeling of pulse response of the optical system to a point object by the Monte Carlo method and determination of  $k=k(t,\omega)$ , where  $\omega$  is spatial frequency by means of a Hankel transform. Special laboratory experiments were performed with a diffusely radiating object with an angular size of  $0.37 \cdot 10^{-3}$  rad. The scattering medium was a solution of milk in water. An extreme was found on the curve of distortion as a function of  $t$ . Figures 4, references 8 Russian. [39-6508]

#### ANOMALOUS BACKSCATTERING OF OPTICAL EMISSION IN STRATIFIED SOLUTION

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 37, No 3, 5 Feb 83 (manuscript received 24 Dec 82) pp 147-149

BUNKIN, F. V., DAVYDOV, M. A., KITAYEV, N. P., LYAKHOV, G. A., SHIPILOV, K. F. and SHMAONOV, T. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The paper gives the results of experimental studies of the optical properties of stratified solutions. A cell with a water solution of  $\gamma$ -collidine was exposed to a ruby laser pulse of 1 ms duration at energy of 1 J. The emission emanating from the cell was focused by a lens on a ruby amplifier. The output beam of the amplifier was coupled through an iris to a selector made up of a stack of plane-parallel plates. The spectra, time and energy parameters of the emission were measured as a function of the temperature in the cell from 5.7°C to 65°C. At 44-47°C, the initiating pulse caused self-excitation of a giant pulse with duration of 50 ns and energy of 1 J. The effect is attributed to feedback introduced by the cell containing the collidine solution. The feedback mechanism is anomalous backscattering by concentration fluctuations which explains the temperature selectivity. Figures 3, references 2 Russian. [28-6610]

#### PARAMETRIC INTERACTION OF OPPOSED LIGHT WAVES OF LIKE FREQUENCY

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 37, No 3, 5 Feb 83 (manuscript received 3 Nov 82, after revision 28 Dec 82) pp 150-152

TABIRYAN, N. V., Yerevan State University

[Abstract] On the basis of theoretical analysis, the author predicts parametric interaction of light waves propagating in opposite directions on the same frequency. The effect is due to the presence of a constant magnetic field in the interaction medium, which may be either an externally applied

field or one arising from spontaneous magnetization of the medium. It is assumed that the waves propagate in a medium with reactive (nonabsorbing) nonlinearity. Energy exchange between the waves takes place as a result of spatial modulation of the vector of gyration of the magnetic medium by the interfering light fields. The gain is a threshold function of power density of the strong wave, and depends on the degree of its circularity. Amplification is maximum with linear polarization of the strong wave, and zero when the wave is circularly polarized. References 3 Russian. [28-6610]

#### DEPHASING EFFECTS IN STEADY-STATE AND UNSTEADY SPECTROSCOPY

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 37, No 1, 5 Jan 83 (manuscript received 4 Nov 82) pp 14-18

D'YAKOV, Yu. Ye., Moscow State University imeni M. V. Lomonosov

[Abstract] Unsteady spectroscopy is a recent development in which short light pulses are used for excitation of a transition. In this case, the time response of the medium, i. e. its Green's function  $h(t)$  must be known to describe the experiment. The same problem is of interest for correlation spectroscopy, as the correlation function of a field that has passed through a resonant medium is also expressed in terms of  $h(\tau)$ . In unsteady (and correlation) spectroscopy, the "dephasing time"  $\tau_f$  corresponds to line width  $\Delta\omega$  measured in steady-state frequency spectroscopy. This parameter can be defined as the time required for the function  $h(t)$  to fall to a certain level ( $h(\tau_f)$ :  $h_{\max} = e^{-m}$ ). Time  $\tau_f$  coincides with the duration of polarization pulse  $P_a(t)$  excited by a very short external field pulse. The author determines the Green's function that describes the time response of a medium to a resonant field for arbitrary pressure  $p$  and correlation  $B(\tau)$  of dephasing. The effect of increased dephasing time corresponding to minimum  $\Delta\omega(p)$  is discussed, as well as identification of  $B(\tau)$  with respect to  $h(t)$ . Theoretical results are confirmed by picosecond Raman spectroscopy of hydrogen in the range of 0.01-10 atmospheres. Figure 1, references 10: 1 Russian, 2 Western. [29-6610]

## RADIOMETER FOR 6-mm BAND WITH QUANTUM TRAVELING-WAVE AMPLIFIER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 3, Jan 83  
(manuscript received 7 Jul 82) pp 611-614

KISLYAKOV, A. G., CHERPAK, N. T., academician, UkSSR Academy of Sciences, SHESTOPALOV, V. P., MAL'TSEV, V. A., REVIN, I. D., SMIRNOVA, T. A., LEBSKIY, Yu. V., CHERNYSHEV, V. I., SKRYNNIK, B. K. and APAYEV, M. M., Institute of Radio Physics and Electronics, UkSSR Academy of Sciences, Khar'kov; Institute of Applied Physics, USSR Academy of Sciences, Gorkiy

[Abstract] The research program on the RT-25 x 2 radiotelescope of the Institute of Applied Physics has necessitated development of a radiometer in the 40-47 MHz frequency band. The device incorporates a quantum paramagnetic traveling-wave amplifier that operates in the same frequency band. Such an amplifier considerably reduces the noise temperature of the reception system, bringing fluctuation sensitivity to thousandths of a degree. The active crystal of the amplifier is andalusite with  $\text{Fe}^{3+}$  ions. Gain is 20-30 dB, and noise temperature at the input flange does not exceed 25 K. Time of continuous operation at 1.7 K is at least 9 hours. It should be possible to make a quantum paramagnetic traveling-wave amplifier with analogous characteristics that operates in the 4-mm band. Figures 2, table 1, references 12: 8 Russian, 4 Western.  
[26-6610]

INVESTIGATION OF  $\text{H:LiNbO}_3$  WAVEGUIDES

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 2, 26 Jan 83 (manuscript received 27 Oct 82) pp 72-75

BURITSKIY, K. S., ZOLOTOV, Ye. M. and CHERNYKH, V. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] A method is described for making lithium niobate graded-index optical waveguides, and a detailed investigation is made of the profile of the refractive index in such waveguides. The waveguides were made by diffusion of  $\text{H}^+$  ions and Z-cuts of a lithium niobate crystal from a melt of benzoic acid ( $\text{C}_6\text{H}_5\text{COOH}$ ). Two specimens were made with diffusion time of 1 1/2 hours and 3 hours. These waveguides propagated only extraordinary (E-) waves. Spectra of the effective index of refraction were analyzed on wavelengths of 0.44, 0.63 and 1.06  $\mu\text{m}$  by determining the angles of exit from a photoresistive grating. Plots of the distributions of increase in the index of refraction in  $\text{H:LiNbO}_3$  waveguides show that the increment reaches 0.17 for a wavelength of 0.63  $\mu\text{m}$ . Figures 2, references 3 Western.  
[31-6610]



## WIDE-BAND MIRRORS FOR EXTREME ULTRAVIOLET AND SOFT X-RADIATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 266, No 3, Sep 82  
(manuscript received 6 May 82) pp 610-612

VINOGRADOV, A. V., KONOPLEV, N. A. and POPOV, A. V., Physics Institute  
imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Previous research has shown that considerable reflectivity in the soft x-ray region can be obtained by using multilayered periodic structures of weakly reflective materials. However, such reflectors are sensitive to wavelength and angle of incidence. In this paper, the authors consider the feasibility of developing wide-band reflectors for this spectral region. The analysis is based on considering sequential reflection of a beam incident at a small angle  $\theta$  on the spherical surface of a material with complex permittivity  $\epsilon$ . It is shown that a beam can be more effectively turned by a spherical surface than it can be reflected by a plane mirror if  $0 < \text{Re } \epsilon \leq 1$ , and  $\text{Im } \epsilon \ll 1$ , which is just the situation to be expected in the soft x-ray region. Experiments with gold and silver mirrors based on this principle show that deflecting and reflecting components can be made for the wavelength range of 50-150 Å with efficiency of 20-50%. Figure 1, references 12: 7 Russian, 5 Western.  
[24-6610]

INTEGRATED-OPTICS HIGH-SPEED ANALOG-TO-DIGITAL CONVERTER

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 4,  
26 Feb 82 (manuscript received 9 Oct 82) pp 218-222

DOKHIKYAN, R. G., KARINSKIY, S. S., MAKSIMOV, V. F. and POPKOV, V. T.,  
Radio Engineering Institute, USSR Academy of Sciences, Moscow

[Abstract] High-speed signal conversion at rates of 1-2 GHz is made possible by combining a pulse laser and integrated-optics modulators with single-level high-speed electronic comparators. Such a device was built and used for converting an analog signal to four-digit Gray code in the pulse mode. The device includes four interferometer-type modulators in waveguide channels with a rutile prism at the common entrance for feeding light pulses and with control electrodes simultaneously receiving the analog signal to be converted, with a constant voltage also applied for producing a constant phase shift in the modulator channels. The light pulses exiting from each modulator channel are focused by a lens array onto the inlet of the optical fiber transmitting them to the corresponding photoreceiver. The photoreceiver output signals, after amplification, are fed to the corresponding single-level comparator and here "1"s and "0"s are selected on the basis of comparison with a threshold level. A sinusoidal voltage from a 90 MHz oscillator resets the comparators after each selection and also controls the acoustooptic shutter for mode locking in the operation of the YAG:Nd laser. The latter emits pulses of 1.0 W power and 1 ns duration at the  $\lambda = 1.06 \mu\text{m}$  wavelength and a 180 MHz repetition rate. The modulators were produced by thermodiffusion of titanium in  $\text{LiNbO}_3$  plates in an argon atmosphere. Each photoreceiver consists of an LDF-2 detector and a transistor amplifier with 40 dB voltage gain. Each comparator is a discriminator with 1IZ08G tunnel diode. A conversion speed of 200 MHz with a 4-6 bits accuracy was attained in the experiment. The authors thank V. Ye. Golubkov and D. F. Zaytsev for assistance and tuning the electronic part of the device. Figures 3, references 3:  
1 Russian, 2 Western.  
[35-2415]



## INFRARED HOLOGRAPHY ON FTIROS MATERIAL USING CO<sub>2</sub> LASER

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 2,  
26 Jan 83 (manuscript received 10 Oct 82) pp 76-78

ZAKHARCHENYA, B. P., CHUDNOVSKIY, F. A. and SHTEYNGOL'TS, Z. I.

[Abstract] FTIROS heat-sensitive material is studied as a prospective medium for reversible holographic recording on a wavelength of 10.6  $\mu\text{m}$  [see Ye. P. Zakharchenya, I. K. Meshkovskiy, Ye. I. Terukov, F. A. Chudnovskiy, PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI, Vol 1, No 8, 1975]. Information recording on this material is based on a thermal process: metal-semiconductor phase transition in a layer of vanadium oxides as the material is heated to about 65°C. Analysis of the reflection spectrum has shown that low absorption on the 10.6  $\mu\text{m}$  wavelength lowers the sensitivity of the material in registration of CO<sub>2</sub> laser emission as compared with sensitivity in the visible and near-infrared. It was found that a film of SiO<sub>2</sub> applied by electron-beam sputtering in vacuum enhances absorption of the material, ensuring absorption of about 80% of the incident CO<sub>2</sub> laser radiation. After 1000 cycles of recording and erasure with exposure of 10<sup>-2</sup> J/cm<sup>2</sup>, no fatigue phenomena were observed in the recording medium. The improved FTIROS material with SiO<sub>2</sub> film had a threshold sensitivity of 8·10<sup>-3</sup> J/cm<sup>2</sup>, threshold of destruction of 0.76 J/cm<sup>2</sup> and diffraction efficiency of 0.52. Figure 1, table 1, references 6: 5 Russian, 1 Western.  
[31-6610]

## ELECTRO-OPTICAL STUDIES OF SURFACE DISCHARGE DEVELOPMENT AND RETURN LEADER FORMATION

Leningrad PIS'MA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 9, No 2,  
26 Jan 83 (manuscript received 12 Jul 82) pp 89-94

DASHUK, P. N., DEMENT'YEV, V. A. and YARYSHEVA, M. D.

[Abstract] Development of a surface discharge is studied in the leader stage, and also at the instant immediately following discharge closure of the spark gap. The problem of determining channel dimensions and their time behavior is considered. An optoelectronic KADR4-31S photographic recorder was used with U-72M light amplifier synchronized with an I2-7 or 6 LOR-04 oscilloscope for measuring the voltage across the leader channel of the surface discharge, the current through it and the rate of growth of the leader. Discharge was in air at atmospheric pressure over the surface of mylar and glass. It was observed that a return leader is always formed that starts from the second electrode after the head of the direct discharge has reached it. This return leader is considerably brighter and moves much faster than the leader of the direct discharge. The effect is attributed to neutralization of the charge on the surface of the dielectric that arises with advancement of the direct leader of the surface discharge.

The enhanced emission intensity of the return leader channel is due to recombination processes in the nonequilibrium plasma of the direct leader. Upon reaching the first electrode, the brightness of the reverse leader channel rapidly fades, and is followed by the final phase of a bright flash over the entire surface discharge channel. A brief description is also given of the dynamics of discharge development. The results of this research are suggested as initial material for a model of surface discharge formation and calculation of discharge parameters. Figures 2, table 1, references 5 Russian.  
[31-6610]

DEPENDENCE OF BEAM-PLASMA INSTABILITY ON TRANSVERSE DIMENSIONS OF ELECTRON BEAM

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 1, Mar 83  
(manuscript received 12 Jul 82) pp 93-97

AZAROVA, O. N., IVANOV, A. A. and LEVADNYY, G. B., Institute of Atomic Energy imeni I. V. Kurchatov, Moscow

[Abstract] The fraction of energy transferred from an electron beam to a plasma has been found to vary widely in different experiments. The cause of this discrepancy could be sought in a decrease of the instability increment as the wavelength of the energy swing becomes comparable with the diameter of the electron beam when the plasma density is sufficiently high. This possibility is examined, assuming a homogeneous plasma in the interaction space so that the effects of boundedness are governed by the beam diameter only. The dependence of beam-plasma instability on the beam diameter is analyzed accordingly, in the kinetic approximation, with the plasma treated in the hydrodynamic approximation and the behavior of the electron beam described by distribution functions. The complete system of three linearized first-order ordinary differential equations of beam-plasma interaction reduces to a single second-order partial differential equation solvable by the method of successive approximations. The zeroth approximation yields the frequency of natural Langmuir oscillations, the first approximation yields the mean instability increment for specific initial potential perturbations. This increment is evaluated, taking into account the condition of orthogonality, and normalized to the maximum increment during the kinetic stage. Results obtained by integration with respect to time indicate that when the electron beam is thin, then its relaxation and the transfer of energy to the plasma will be inhibited. By matching the beam and plasma parameters, therefore, it is possible to attain either maximum beam relaxation or cutoff of instability. Article was presented by Academician B. B. Kadomtsev 5 May 1982. References 14: 11 Russian, 3 Western.  
[41-2415]

## HIGH-CURRENT PULSING PROTON SOURCE

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 53, No 2, Feb 83  
(manuscript received 18 Mar 82) pp 258-263

DAVYDENKO, V. I., DIMOV, G. I., MOROZOV, I. I. and ROSLYAKOV, G. V.,  
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Sciences, Novosibirsk

[Abstract] An experimental proton source has been developed, built and tested by the authors for starting the atom injectors in the AMBAL ambipolar plasma collector. Its three principal components are a generator of highly ionized hydrogen (proton) plasma jet, a permeable toroidal winding which acts as "magnetic wall" and transforms the jet into a uniform stream, and a four-electrode ion-optical device for ion beam extraction. Plasma is generated by pulses of arc discharge with a cold cathode in hydrogen. Its density distribution beyond a center hole in the anode at distances much larger than the hole diameter is, assuming free expansion in vacuum, approximately  $j(x,z) = I/(-z)^2(1 + x^2/z^2)^2$  ( $I$  - total ion current,  $z$  - axial coordinate,  $x$  - radial coordinate), corresponding to collisionless gas discharge through a small orifice. A magnetic field applied to the discharge increases the plasma yield beyond the anode up to threefold. Instability occurs above a critical magnetic field intensity which depends on the discharge current, with plasma current fluctuations at frequencies of 0.1-10 MHz. Three of the four electrodes for extraction of ions from the emitting plasma stream, rings of stainless steel, have meshes of fine molybdenum wire welded onto their end faces. The first mesh, floating, nearest to the plasma is at the anode potential  $U$ . The second mesh, focusing, 1 mm behind the first one is at a  $+0.93U$  potential. The third mesh, barring secondary electrons, 3.5 mm behind the second one is at a slightly negative  $-0.03U$  potential. The fourth electrode has no molybdenum mesh, secondary plasma replacing the latter. Under optimum conditions the ion current varies as  $U^{3/2}$  and reaches 37 A with an ion energy of 25 keV. Mass-spectrometric analysis has established that the beam contains 97% protons + 2%  $H_2^+$  + 1%  $H_3^+$  + 1% heavy ions (mass 12-40). The proton source generates pulses of 200 J energy at a controllable repetition rate of 0.2-2 Hz, with an overall gas efficiency of 5%. The cathode life is  $10^5$  pulses. On the basis of this prototype, there is a START-2 proton source being developed for beam currents up to 80 A. The authors thank P. A. Zhuravlev and V. A. Novikov for assistance in building and using the proton source, also V. Ya. Savik for developing the basic supply circuits. Figures 6, references 9 Russian.  
[37-2415]

# SPECTRAL MAKEUP OF DT-NEUTRONS IN PLASMA FOCUS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI

in Russian Vol 37, No 1, 5 Jan 83 (manuscript received 8 Nov 82) pp 18-21

GOLUBEV, V. I., MAKEYEV, N. G., PASHCHENKO, Ye. S., RUBTSOV, N. V.,  
SPIRIN, A. A., SURSKIY, O. K., TSUKERMAN, V. A. and CHEREMUKHIN, G. N.,  
Institute of Atomic Energy imeni I. V Kurchatov, USSR Academy of Sciences

[Abstract] The paper gives the results of studies of the spectral makeup of DT-neutrons produced in the plasma focus of a gas-discharge chamber with configuration close to fixed geometry. When a capacitor bank is discharged across this chamber with stored energy of 60 kJ, pressure of deuterium-tritium mixture of 18-23 mm Hg and initial voltage of 18.5-21 kV, the integral yield is  $10^{11}$  neutrons per pulse with duration  $\tau_{0.5} \approx 20$  ns. The spectral composition of the DT neutrons was measured by the time-of-flight method simultaneously in three directions relative to the axis of the discharge chamber:  $0^\circ$  (direction from anode to cathode),  $90^\circ$  and  $180^\circ$ . Analysis of the results shows that the centers of mass of interacting particles move with velocities of up to  $(1-2) \cdot 10^8$  cm/s from anode to cathode. Broadening of spectral distribution in the  $90^\circ$  direction shows radial components of  $7 \cdot 10^7$  cm/s. The results seem to contradict a thermonuclear mechanism of DT-neutron formation in the plasma focus. Figures 3, references 8: 3 Russian, 5 Western.  
[29-6610]

## STRESS, STRAIN AND DEFORMATION

UDC: 539.89

HIGH PRESSURE AND TEMPERATURE APPARATUS WITH WORKING VOLUME  $85 \text{ cm}^3$  OPERATING AT CARBONADO SYNTHESIS PRESSURE AND TEMPERATURES FOR 50,000 T PRESS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 268, No 2, Jan 83  
(manuscript received 25 May 82) pp 357-359

SEMERCHAN, A. A., KUZIN, N. N., DAVYDOVA, T. N. and BIBAYEV, K. Kh.,  
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[Abstract] The authors' institute is working on three stage high pressure and a temperature apparatus for the production of large single crystal and polycrystalline superhard substances such as diamond. This work describes the operating principle and characteristics of a high pressure and temperature apparatus capable of generating the pressure and temperature required to synthesize carbonado in a working volume of  $85 \text{ cm}^3$ . The VK-6 alloy dies are pressed into a set of supporting rings made of heat treated alloy steel inside safety rings made of unalloyed steel without heat treating. A diagram and photograph of the apparatus are presented. The pressure calibration curve as a function of press force is presented. The apparatus has been used in a 6000-7000 T press to synthesize large, high strength, highly abrasive diamond polycrystals up to 25 mm in diameter and 17 mm high. Figures 4, references 6 Russian.  
[39-6508]



## THERMODYNAMICS

UDC 536.75:539.2

### THERMODYNAMICS OF VACANCIES IN ULTRAFINE-DISPERSE SYSTEMS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 269, No 1, Mar 83  
(manuscript received 4 Oct 82) pp 101-104

MOROKHOV, I. D., ZUBOV, V. I. and FEDOROV, V. B., Institute of Metallurgy  
imeni A. A. Baykov, USSR Academy of Sciences; Friendship of Peoples  
University imeni P. Lumumba, Moscow

[Abstract] The behavior of vacancies in an ultrafine-disperse substance is analyzed on the basis of the corresponding equation of thermodynamics for their concentration, considering that the Laplace excess pressure above the pressure in a bulk specimen tends to "expel" vacancies from a particle and thus lower their concentration while the free surface energy tends to lower the thermodynamic potential of vacancy formation and thus raise their concentration. The substance is regarded as a weak solution of vacancies and its particles are assumed to be spherical. The dependence of the thermodynamic potential of vacancy formation on the particle size is determined, first for an almost homogeneous binary solid solution, in the quasi-chemical approximation so that not only the thermodynamic bond between two kinds of atoms but also the chemical potentials of the respective "pure subsystems" are taken into account. An analysis of the resulting relations indicates that integral rather than differential chemical potentials are involved here. Further calculations yield an expression for the vacancy concentration as an exponential function of pressure and temperature. For particle sizes in the Angstrom range one can approximate the dependence of the specific free surface energy on the particle radius with the Gibbs-Tolmen-Koenig-Buff equation. The vacancy concentration approaches a finite limit which is either higher or lower than the concentration in a bulk specimen, depending on whether the effect of free surface energy or the effect of Laplace pressure predominates. Article was presented by Academician Ye. P. Velikhov 7 August 1982. References 12: 6 Russian, 6 Western.  
[41-2415]

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